Quarterly Report
July - September 1994

Michael D. King and Si-Chee Tsay
Goddard Space Flight Center
Greenbelt, MD 20771

Abstract

Our major achievement of this quarter is twofold: (1) extensive study on MAS calibration to establish proper procedures, and (2) analyses of ASTEX data on MAS remote sensing / retrievals and *in situ* microphysical data.

I. Task Objectives

With the use of related airborne instrumentation, such as the MODIS Airborne Simulator (MAS) and Cloud Absorption Radiometer (CAR) in intensive field experiments, our primary task objective is to extend and expand algorithms for retrieving the optical thickness and effective radius of clouds from radiation measurements to be obtained from the Moderate Resolution Imaging Spectroradiometer (MODIS).

II. Task Progress

a. MODIS-related Instrumental Research

During this quarter, we have spent a considerable amount of time and effort on the MAS calibration issue. On the MAS radiometric calibration, data for the different gain settings were added for the Ames 20-inch integrating hemisphere and 30-inch sphere sources, and the radiance values for the Ames 30-inch sphere and the Goddard 48-inch hemisphere sources were updated from John Cooper's recent calibrations. Optronics data for independent calibrations were also added. The radiance / count values were computed for data from all three sources using John Cooper's radiance values as well as using Optronics radiance values (only for the 30-inch source). At gain setting of 1, the radiance / count values were in excellent agreement for the three sources when using Cooper's calibration alone for each source. However, comparing the MAS calibration using Cooper's data to Optronics' for the 30-inch sphere shows good agreement in channels 2 and 3 (0.66 and 0.87 µm) but about a 15% difference in the near-IR channels 4-7. Tom Arnold is looking into this disagreement to see if it is true also for the 20-inch hemisphere data.

Another investigation of MAS radiometric calibration was conducted using differences in the 20-inch hemisphere when operated at 2 slightly different current levels (at 2.78 and 2.8 volts). John Cooper calibrated the hemisphere mostly while operating at 2.8 volts but also some at 2.78 volts (5, 3, and 2 lamps). Analyses of the 20-inch data show that the 2 current levels differ in radiance by a few percent for MAS channels 2 and 3 but probably less than 1% for the longer wavelength channels. To avoid this problem altogether for future calibrations, hardware to regulate the 20-inch hemisphere current level at a fixed value is on order.

The BOREAS mission (see below) was the first deployment of the MAS onboard the NASA C-130 aircraft. Prior to each flight, radiance measurements of the Ames 20-inch hemisphere were recorded by the MAS, in which the 20-inch hemisphere was placed very close to the MAS (as was necessary due to location of the instrument under the fuselage only about 2 feet above the ground). This causes 'loading' of the hemisphere radiance and thus spurious radiance values. The loading is not linearly dependent on distance from the instrument. Analysis of this data set is underway by Tom Arnold together with the Ames personnel.

Another issue pursued during this quarter was the characterization of MAS spectral channels. The MAS was sent to Stennis Space Center where spectral calibrations for all 50 channels were performed on August 17-19. Analyses of these data are currently underway. Calibration sensitivity studies of gaseous absorption on integrating sphere output were conducted by Steve Platnick using Monte Carlo simulation of the photon path length distribution within the sphere. MAS measurements are needed to compare with the model results.

The 50-Channel Data Acquisition/Digitizer System (DAS) is a nearly completed part of the data system for the MAS. It is housed in an enclosure inside the System Box along with a host Ampro Computer Board and an Exabyte Tape Drive. The DAS was developed at the Space Sciences Laboratory at UC Berkeley and built by Berkeley Camera Engineering. Upon completion of the DAS, each channel will have digital control of the input gain with a second stage gain and offset to guarantee optimal ADC performance, and consists of the following features: (1) a low noise instrumentation amplifier with selectable gains of 1, 10 and 100 via digitally controlled relays, (2) a second instrumentation amp that has digitally controlled gains of 1, 10, 100 and 1000, and an offset adjustment, (3) a two-channel, 16-bit, 100 kHz A/D Sample/Hold Converter configured for a bipolar analog input and a 2nd compliment digital output in Synchronous Self-Clocking Mode for optimum performance with 4× oversampling to reduce aliasing from system noise while eliminating ringing effects seen in all analog filters, and (4) an onboard voltage regulation.

Post-flight CAR calibrations for the MAST (Monterey Area Ship Track) experiment, based in Monterey CA during June 1994, were completed on September 7. Subsequent to this calibration, all optics of the CAR were cleaned and recalibrated prior to the SCAR-C (Smoke, Clouds And Radiation-California). Analyses of these data are currently underway. Some localized anomalies of CAR radiance were observed due to a quick change in manual gain during a scan cycle. Max Strange is looking into an addition of a small circuit board to the panel box to synchronize the gain change within the scan cycle that will improve data collection.

b. MODIS-related Data Processing and Algorithm Study

The MAS 50-channel quickview system has been developed using IDL by Dave Augustine and Liam Gumley and was used to review all MAS data from TOGA COARE and CEPEX to find likely candidate flights for visible/near-IR in-flight calibration. Timing tests for a less ambitious quickview program (using only IDL graphics, with no Widgets) did show that it runs fast enough to keep up with the data volume (about 5.5 times the data acquisition speed). However, the speed is really limited by the rate of transferring the data volume from the Exabyte tape, and hence the 50 channel quicklook system could only run at about 1.5 times the data acquisition speed. Thus, it was suggested that a large hard disk be used in the field to dump the tape data after each MAS flight. The data on the hard disk would then be used in conjunction with the quicklook system to provide acceptable viewing speed.

Liam Gumley developed a way to display MAS images on a map base in a standard map projection, for a quick overview of an entire ER-2 mission. The science quicklooks generated during Level-1B MAS processing were used instead of Level-1B radiance data for speed. Navigation data for each pixel in the quicklook images were computed using the start and end points of the flight line derived from the flight summary file. The images were sized to provide adequate detail, without consuming too much memory during gridding. All quicklook images from FIRE-II, ASTEX, SCAR-A, and MAST were processed to produce flight line mosaic images for all flights in these missions. In future missions, this will become part of the Level-1B processing sequence. The MAS World Wide Web home page has also been established by Liam Gumley and was retrieved more than 680 times during the months of July and August (not including sub pages, and accesses from 'redback' workstation).

The MAS ASTEX data have been processed through the Cloud Retrieval Algorithm by Menghua Wang for 42 cloudy flights. Three output files were generated: (i) retrieved cloud optical thickness, (ii) effective particle radius which is an average of two-channel (0.664 and 2.142 μm) and three-channel (0.664, 1.621, and 2.142 μm) algorithm values, and (iii) %-difference of the retrieved effective particle radius of these two methods. The results for the %-difference represent the retrieval accuracy (both spectral/radiometric calibration and aerosol/ice cloud contamination), since theoretically for plane-parallel water clouds the retrieved effective particle radius using these two different methods must be consistent. On the other hand, the %-difference may be viewed as an indication of the effect of cloud inhomogeneity. The retrieved cloud optical thickness and effective particle radius of ASTEX data are presented as the marginal and joint probability density functions for statistical interpretation and to compare with *in situ* measurements. The corresponding microphysics data that we have examined from the University of Washington C-131A aircraft include radar altitude, condensation nuclei, droplet concentrations, liquid water content and effective particle radius from the PVM, FSSP and OAP probes. These results were presented in the Lisbon Conference at the ASTEX special section. In general, the statistics of MAS retrieved effective particle radius are in reasonable agreement with *in situ* measurements. Similar results were obtained by Steve Platnick in comparing AVHRR 3.75 µm retrievals with corresponding *in situ* measurements.

Steve Platnick further developed codes (a simple analytical and/or empirical fitting formulas for reflection and emission calculations) to be used in radiative transfer library calculations, specifically for MAS data acquired during the MAST experiment. A revised definition of cloud susceptibility valid at 3.7 µm (instead of the usual definition valid in the visible wavelength region) is also studied and will be used in MAST analyses.

c. BOREAS experiment

The MAS participated in the BOREAS campaign (Boreal Ecosystem-Atmosphere Study, based in Thompson, Canada during July-August 1994) for four flights (July 21 and 24, August 4 and 8). Twelve MAS bands were selected and centered at 0.547, 0.664, 0.745, 0.786, 0.834, 0.875, 0.945, 1.623, 2.142, 3.90, 11.002 and 12.032 µm with 8-bit resolution. The absolute visible and near-infrared calibrations for BOREAS will be derived by Ames from the pre- and post-flight calibration over the Ames 30-inch sphere source.

d. SCAR-C experiment

Both MAS and CAR participated in the SCAR-C field experiment (Smoke, Clouds and Radiation-California; September-October 1994). The SCAR-C MAS configuration was as follows: 0.547, 0.664, 0.875 µm at 0.8 reflectance saturation (*R*), two 1.623 µm bands at high (786 K/2.0 *R*) and low (650 K/0.2 *R*) settings, 1.88 µm (0.2 *R*), 2.142 µm (580 K/0.83 *R*), two 3.90 µm bands at low (330 K/0.39 *R*) and high (500 K/28.5 *R*) settings, and finally two regular thermal channels at 11.002 and 12.032 µm. The CAR spectral bands were selected at 0.47, 0.67, 0.30, 0.87, 1.03, 1.27, 1.22, 1.55, 1.64, 1.72, 2.10, 2.20, and 2.30 µm. Both MAS and CAR operated for about 30 flight hours. Three coordinated measurements of the ER-2 and C-131A over smoke plumes, prescribed forest burns and wildfires were obtained in September.

e. MODIS-related Services

1. Meetings

1. Michael D. King attended the BOREAS, experiment in Saskatchewan, a SCAR-B workshop in Brasilia, and the EOS Payload Panel meeting in Landover, MD;

2. Michael D. King, Si-Chee Tsay and Steven E. Platnick attended the 1st

International Airborne Imaging Spectrometer Calibration Workshop, Strasbourg, France on 11 September 1994;

3. Michael D. King, Si-Chee Tsay and Steven E. Platnick attended the 1st International Airborne Remote Sensing Conference and Exhibition, Strasbourg, France on 12-15 September 1994 and M. D. King presented a paper entitled "MODIS Airborne Simulator: Status, calibration, and Earth remote sensing applications;"

4. Menghua Wang attended the MODIS test data workshop at Polson, MN on 20-22 September 1994 to report on our activities related to the MODIS cloud retrieval algorithms developed by the Cloud Retrieval Group;

5. Si-Chee Tsay attended the 2nd International Conference on Air-Sea Interaction and on Meteorology and Oceanography of the Coastal Zone, Lisbon, Portugal on 22-27 September 1994 and presented a paper entitled "Remote sensing and in-situ measurements of cloud radiative and microphysical properties in ASTEX;"

6. Steven E. Platnick attended the European Symposium on Satellite Remote Sensing, Rome, Italy on 26-30 September 1994 and presented a paper entitled "Status and calibration of the MODIS Airborne Simulator: for Earth remote sensing applications."

2. Seminars

1. None.

III. Anticipated Activities During the Next Quarter

a. Complete the MODIS Beta-II software delivery to SDST, including cloud retrieval algorithm, new lookup tables, and necessary interface (input test data and expected outputs);

b. Complete the MODIS Algorithm Theoretical Basis Document version 3, to be submitted to the EOS Project Science Office in November 1994;

c. Continue to analyze FIRE-II Cirrus and ASTEX data gathered by the MAS and CLS, as well as theoretical studies, and prepare manuscripts for submission to journals;

d. Compare retrieved cloud parameters from the 3.75 µm channel with those obtained from the 0.665, 1.623 and 2.142 µm channels, and look into the spectral signature of vertical profile in effective particle radius;

e. Continue to analyze surface bidirectional reflectance measurements obtained during the Kuwait Oil Fire, LEADEX, ASTEX and SCAR-A experiments;

f. Process and analyze MAS data obtained from the MAST field campaign and present preliminary results of this analysis at the Science Team meeting in April 1995;

g. Attend MODIS and CERES Science Team meetings at GSFC (October 12-14) and LaRC (November 30 - December 2), respectively.

IV. Problems/Corrective Actions

No problems that we are aware of at this time.

V. Publications

1. Gumley, L. E., and M. D. King, 1994: Remote Sensing of flooding in the US upper midwest during the summer of 1993. *Bull. Amer. Meteor. Soc.*, in press.

2. Wielicki, B. A., R. D. Cess, M. D. King, D. A. Randall, and E. F. Harrison, 1994: Mission to Planet Earth: Role of clouds and radiation in climate. Submitted to *Bull. Amer. Meteor. Soc.*

3. Platnick, S. E., 1994: Photon path lengths in integrating spheres and the effect of gaseous absorption on radiance output. NASA GSFC internal report.

4. King, M. D., D. D. Herring and D. J. Diner, 1994: The Earth Observing System (EOS): A space-based program for assessing mankind's impact on the global environment. *Opt. Photon. News* (in press).